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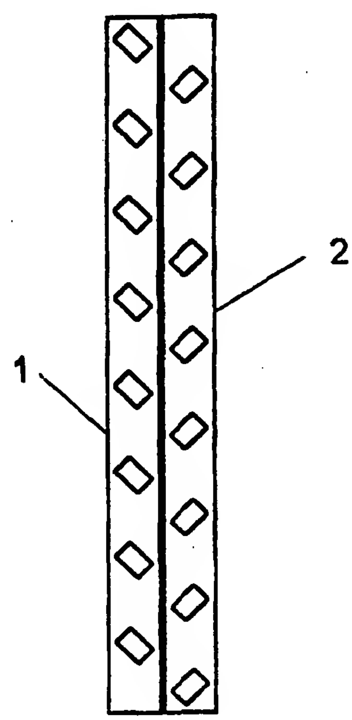
With amended claims and statement.

(54) Title: IMPROVEMENT OF POLARIZATION ISOLATION IN ANTENNAS

(57) Abstract

An antenna presenting improved polarization isolation is disclosed which presents at least two columns of rectangular micro-strip or patch elements which each has a single, linear polarization. Each column presents radiation elements of either about +45 or −45 degrees. At least two such columns are combined such that an antenna is obtained which then becomes dual polarized. Furthermore the columns are arranged such that the patches are alternately sidewise displaced to form a herringbone pattern. In other words a next patch of one column is placed on the symmetry lines through nearby parches of the other column. In this way the coupling between the patches is minimized and a high isolation is achieved between the two states of polarization. The achieved two linear states of polarization are utilized separately for polarization diversity. Furthermore in the preferred embodiment the structure of the antenna is designed to compensate for pointing errors between the columns due to unsymmetrical ground-planes.



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Improvement of polarization isolation in ant nnas

TECHNICAL FIELD

The present invention relates to polarization isolation and more particularly to a method and an arrangement for further increasing the isolation between antennas having two separate states of polarization in a microwave antenna.

BACKGROUND

In modern communication systems, for instance for base stations serving cellular mobile telephones, antennas of different states of polarization are utilized. Traditionally vertical polarization is used for both the transmitter and receiver and utilization of dual antennas with a separation distance for obtaining diversity reception. It was also found that a diversity gain was obtained when using two differently polarized antennas together at the same location, typically a horizontal and a vertical polarization, respectively. It has also been found favorable to utilize receive antennas having ±45° polarization provided that a good isolation is maintained between them.

In this context there are found several documents involving at least two states of polarization. Several documents are also found which address sequentially rotated elements and the way such actions improve various antenna characteristics.

One document WO 89/08933 and also another document GB, A, 1 572 273 disclose a pair of mutually similar antennas. A number of rectangular portions of microstrip conductors are either directly electrically connected to (WO 89/08933) or electromagnetically connected to (GB, A, 1 572 273) two groups of parallel feed conductors. The small radiators are not placed parallel to the feed but form an angle to a vertical line. By connecting the feeders together with a suitable mutual phase difference dual circular states of polarization are obtained. However, the isolation between the connection ports is not discussed, but the isolation between the elements is apparently

to be maintained by the distance between those. Furthermore nothing is mentioned about any particular positioning of the elements.

For antennas polarized for instance ±45° it may be an advantage to utilize single polarized elements. Feeding of single polarized radiation elements is easier to arrange with good matching than with dual polarized elements. To be able to handle both the states of polarization in one column the elements then must be closely placed. If according to the state of the art an antenna column is designed having every second element polarized at +45° and every other element polarized at –45° according to Figure 1 there will be a problem to achieve an isolation of more than 20 dB.

Therefore there is still a desire to find an antenna design, which presents a better isolation than what is achieved in arrays according to the state of the art.

SUMMARY

An antenna according to the present invention is characterized in that it has at least two columns of rectangular micro-strip or patch elements which each has a single, linear polarization. Each column presents radiation elements of either +45 or –45 degrees. At least two such columns are combined such that an antenna is obtained which then becomes dual polarized. Furthermore the patches are alternately sidewise displaced such that they form a herringbone pattern. In other words such a next patch of one column is placed on the symmetry lines through nearby patches of the other column. In this way the coupling between the patches is minimized and a high isolation is achieved between the two states of polarization. The achieved two linear states of polarization are utilized separately for polarization diversity. Furthermore the structure of the antenna is designed to compensate for pointing errors between the separate columns due to unsymmetrical ground-planes.

The method according to the present invention is set forth by the attached independent claim 1 and the dependent claims 2 to 4.

Similarly an antenna arrangement according to the present invention is set forth by the attached independent claim 5 and further embodiments are defined in the dependent claims 6 - 8.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be further described by reference to the attached drawings wherein same reference numbers refer to same or corresponding elements, and in which:

Fig. 1 demonstrates an antenna polarized at ±45° polarized and built up by single polarized elements in the same column according to the state of the art;

Fig. 2 illustrates an antenna built up by single polarized elements in a respective column to form an antenna polarized at ±45° in accordance with the present invention;

Fig. 3 shows in a more detailed view four patches forming a portion of the herringbone pattern illustrated in Fig. 2;

Fig. 4 illustrates a general antenna device designed in accordance with the present invention;

Fig. 5 illustrates a second embodiment of the antenna arrangement according to the present invention for obtaining parallel radiation patterns for the two antenna columns; and

Fig. 6 illustrates a third embodiment of the antenna arrangement according to the present invention for obtaining parallel radiation patterns for the two antenna columns.

DETAILED DESCRIPTION

A method according to the present invention for achieving a better isolation for antennas linearly polarized for instance of the order ±45° is illustrated in Figs. 2 and 3. The antenna is built up with two separate single polarized antenna columns, a first column 1 presenting a linear polarization of about –45° and a second column 2 linearly polarized at about +45°. Column 1 then will contain a number of patch radiators 6 having their polarization plane at about –45 degrees, while column 2 in the illustrative embodiment will contain a corresponding number of patch radiators 8 having their polarization plane at about +45 degrees. The columns are arranged close alongside each other as demonstrated in Fig. 2. In this way a combined dual polarized antenna is obtained. Fig. 3 illustrates how the symmetry lines of the patches 6 and 8, respectively, should cross each other in accordance with the present method to obtain a maximum isolation. This results in an easily visible herringbone pattern characterizing an antenna array according to the present method.

In Fig. 4 is shown a horizontal cross section of a vertically aligned basic antenna array according to Fig. 2. The antenna array consists of the two antenna columns 1 and 2 each presenting a standard back-plane structure. The back-plane structure consists of a backplane 10a carrying studs or a support profile12 holding a laminate 14a presenting slots and distribution network (not shown). In a preferred illustrative embodiment the support profile 12 is made of extruded aluminum, but may as well be made of another non-conducting material. For instance in an illustrative

embodiment, which operates around 1800 MHz, the width of the support profile is of the order 250 mm. The laminate 14a in turn presents a second set of studs 16 carrying a patch laminate 18a at a suitable distance from the slots formed in the laminate 14a. The patch laminate 16a presents patches 6 demonstrating one direction of linear polarization, while a corresponding patch laminate 18b in the column 2 has patches 8, which represent the other polarization.

However, there is one disadvantage with this arrangement in that the ground-plane for vertical column 1 will become unsymmetrical due to the ground-plane of the nearby column 2, and correspondingly the ground-plane of the column 2 will be similarly be affected by the ground plane of column 1. Due to the unsymmetrical ground-planes each column in Fig. 4 will obtain a pointing error in its radiation pattern as is illustrated by the two arrows in Fig. 4 demonstrating a radiation direction for the respective column. This pointing error may be of the order of up to 10 degrees, which is not a negligible value in this context.

Fig. 5 demonstrates a second embodiment of the antenna array according to the present invention in which the radiation direction for each one of the two columns has been corrected. By introducing an angle 20 between the nearby studs or support profiles 12 of the back-plane structures 10a and 10b, the radiation direction of each column will be compensated, such that the radiation directions for both columns will be in parallel. This is advantageous as the two states of polarization at about ±45° are desired to cover exactly the same area seen from a base station utilizing an antenna array according to the present invention.

Fig. 6 demonstrates a third embodiment of the antenna array according to Fig. 4 wherein a wall 24 between the columns 1 and 2 is introduced for minimizing the effect of the ground-plane to the nearby column. This wall is a conducting part and preferably an integral part of the support profile. By

means of the wall 24 the radiation directions of the two columns will now be in parallel as indicated by the arrows.

In the illustrative embodiments reference is made to patch antennas, but it is readily obvious to a person skilled in the art that the principles according to the present description may be used also for other radiation elements, e.g. dipoles or wave-guide slots.

The invention has been described functionally with reference to the drawings related to illustrative embodiments. The more detailed realization can be achieved by a technique, which is well known to persons skilled in the art of microwave antennas. The possibility of an arbitrary combination of different embodiments in order to produce an efficient and appropriate arrangement is also intended to lie within the spirit and scope of the invention.

CLAIMS

1. A method for obtaining a dual polarized microwave antenna array presenting optimal isolation between linear states of polarization of the order ±45° **characterized by** the steps of:

arranging at least two vertical columns containing a number of radiation elements,

arranging a first group of radiation elements in such a vertical column (1) for producing a linear state of polarization at about –45 degrees,

arranging a second group of radiation elements in such a vertical column (2) for producing a linear state of polarization at about +45 degrees,

aligning a column containing the first group of radiation elements in relation to a column containing the second group of radiation element such that a line through a symmetry center of a radiation element in the first group pass through a symmetry center of an adjacent radiation element in a column containing the second group of radiation elements and a column containing the second group of radiation elements in relation to a column containing the first group of radiation element such that a line through a symmetry center of a radiation element in the second group pass through a symmetry center of an adjacent radiation element in a column containing the first group of radiation elements, whereby each radiation element in one group will be positioned centered along a line parallel to the polarization direction and perpendicular to a radiation element in another group.

2. The method according to claim 1, **characterized by** the further step of arranging each radiation element in the form of a rectangular patch (6, 8), whereby these rectangular patches (6, 8) will be appearing like a herringbone pattern in the antenna arrangement.

3. The method according to claim 1, **characterized by** the further step of arranging each radiation element in the form of a dipole element, whereby

the dipole elements will be appearing like a herringbone pattern in the antenna arrangement.

4. The method according to claim 1, **characterized by** the further step of arranging each radiation element in the form of a wave-guide slot, whereby the rectangular wave-guide slots will be appearing like a herringbone pattern in the antenna arrangement.

5. An antenna arrangement for obtaining a dual polarized microwave antenna array presenting optimal isolation between two linear states of polarization of the order ±45° **characterized by**

a first antenna column (1) presenting a number of radiation elements (6) linearly polarized at about -45°,

a second antenna column (2) presenting a number of radiation elements (8) linearly polarized at about +45°,

whereby the first antenna column (1) is vertically aligned with the second antenna column (2) such that a line along the direction of the polarization plane through a symmetry point of a radiation element (6) in the first antenna column (1) passes through a symmetry center of an adjacent radiation element (8) in the second antenna column (2) and a line along the direction of the polarization plane through a symmetry point of a radiation element (8) in the second antenna column (2) passes through a symmetry center of an adjacent radiation element (6) in the first antenna column (1) to thereby obtain an optimum isolation between the first column and the second column.

6. The arrangement according to claim 5, **characterized in** that each antenna column comprises a back-plane structure consisting of a back-plane (10a, 10b) carrying a first set of studs or support profiles (12) holding a first laminate (14a, 14b) presenting slots and a distribution network, the

first laminate carrying a second set of studs (16) holding a second laminate (18a, 18b) forming a number of rectangular patches.

7. The arrangement according to claim 5, **characterized in** that the first column and the second column are mounted with an angle (20) between the inner studs of first set of studs or support profiles (12) for compensating a pointing error between the first antenna column (1) and the second antenna column (2) due to unsymmetrical ground planes.

8. The arrangement according to claim 5, **characterized in** that a separation wall (24) is vertically inserted between the second laminates (18a, 18b) of the first antenna column (1) and the second antenna column (2) for minimizing interaction between the ground planes of the first antenna column and the second antenna column.

AMENDED CLAIMS

[received by the International Bureau on 21 March 2000 (21.03.00); original claims 1 and 5 amended; remaining claims unchanged (3 pages)]

1. A method for obtaining a dual polarized microwave antenna array presenting optimal isolation between linear states of polarization of the order ±45° **characterized by** the steps of:

arranging at least two vertical columns containing a number of radiation elements,

arranging a first group of radiation elements in such a vertical column (1) for producing a linear state of polarization at about –45 degrees,

arranging a second group of radiation elements in such a vertical column (2) for producing a linear state of polarization at about +45 degrees,

aligning a column containing the first group of radiation elements in relation to a column containing the second group of radiation element such that a symmetry line passing through a symmetry center of a radiation element in the first group passes through a symmetry center of an adjacent radiation element in a column containing the second group of radiation elements and a column containing the second group of radiation elements in relation to a column containing the first group of radiation element such that a symmetry line passing through a symmetry center of a radiation element in the second group passes through a symmetry center of an adjacent radiation element in a column containing the first group of radiation elements, to thereby obtain an optimum isolation between the first column and the second column.

2. The method according to claim 1, **characterized by** the further step of arranging each radiation element in the form of a rectangular patch (6, 8), whereby these rectangular patches (6, 8) will be appearing like a herringbone pattern in the antenna arrangement.

3. The method according to claim 1, comprising the further step of arranging each radiation element in the form of a dipole element, whereby the dipole elements will be appearing like a herringbone pattern in the antenna arrangement.

4. The method according to claim 1, comprising the further step of arranging each radiation element in the form of a wave-guide slot, whereby the rectangular wave-guide slots will be appearing like a herringbone pattern in the antenna arrangement.

5. An antenna arrangement for obtaining a dual polarized microwave antenna array presenting optimal isolation between two linear states of polarization of the order ±45° **characterized by**

a first antenna column (1) presenting a number of radiation elements (6) linearly polarized at about -45°,

a second antenna column (2) presenting a number of radiation elements (8) linearly polarized at about +45°,

whereby the first antenna column (1) is vertically aligned with the second antenna column (2) such that a symmetry line along the direction of the polarization plane through a symmetry point of a radiation element (6) in the first antenna column (1) passes through a symmetry center of an adjacent radiation element (8) in the second antenna column (2) and a symmetry line along the direction of the polarization plane through a symmetry point of a radiation element (8) in the second antenna column (2) passes through a symmetry center of an adjacent radiation element (6) in the first antenna column (1) to thereby obtain an optimum isolation between the first column and the second column.

6. The arrangement according to claim 5, **characterized in** that each antenna column comprises a back-plane structure consisting of a back-plane (10a, 10b) carrying a first set of studs or support profiles (12) holding a first laminate (14a, 14b) presenting slots and a distribution network, the first laminate carrying a second set of studs (16) holding a second laminate (18a, 18b) forming a number of rectangular patches.

7. The arrangement according to claim 5, **charact rized in** that the first column and the second column are mounted with an angle (20) between the

inner studs of first set of studs or support profiles (12) for compensating a pointing error between the first antenna column (1) and the second antenna column (2) due to unsymmetrical ground planes.

8. The arrangement according to claim 5, **characterized in** that a separation wall (24) is vertically inserted between the second laminates (18a, 18b) of the first antenna column (1) and the second antenna column (2) for minimizing interaction between the ground planes of the first antenna column and the second antenna column.

STATEMENT UNDER ARTICLE 19

In the INTERNATIONAL SEARCH REPORT two documents, US 4857938 and EP 0360692 have been categorised as document of particular relevance such that the claimed invention by the authorised officer is considered not to be novel or involving an inventive step.

The present invention is characterised in that it consists of antenna elements positioned in a completely symmetrical herringbone pattern with adjacent elements turned in polarisation 90° in relation to each other. It is obvious from lines 24 - 26 of the summary on page 2 (and Figure 3) that a next patch element of one column is positioned on the symmetry lines through the symmetry point of adjacent patch elements of the other column and not only on lines passing through the symmetry point of an element in one column.

In the claims filed this feature is not fully clear as the independent claims did not clearly point out that the lines referred to also constitute symmetry lines regarding the patch elements themselves to obtain the desired complete balanced symmetry. This completely balanced symmetry will guarantee the essentially better isolation aimed at, compared to what is achieved by the disclosed state of the art called upon. Consequently, according to the present invention a complete symmetry in the herringbone pattern is obtained, which is neither obtained by US 4857938, nor by EP 0360692.

We hereby file a set of claims with amended independent claims 1 and 5. The claims 1 and 5 then are phrased in a manner to overcome this deficiency pointed out also by the Examiner in the Swedish Application. The application will hereby no longer be anticipated by the cited documents US 4857938 and EP 0360692.

STATE OF THE ART

Fig. 1

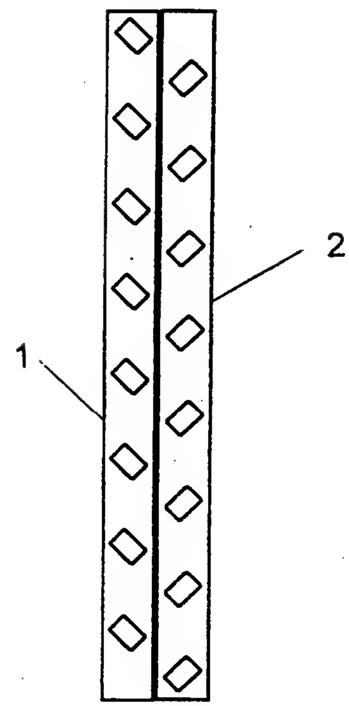

Fig. 2

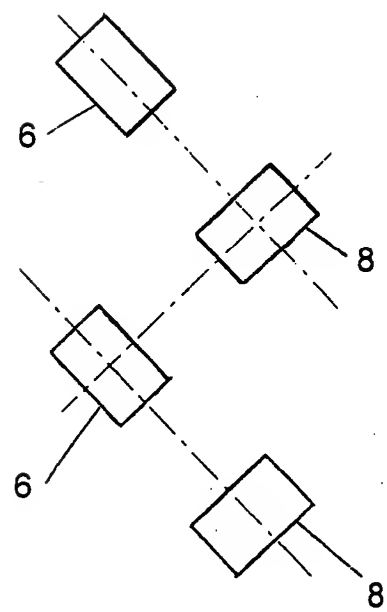

Fig. 3

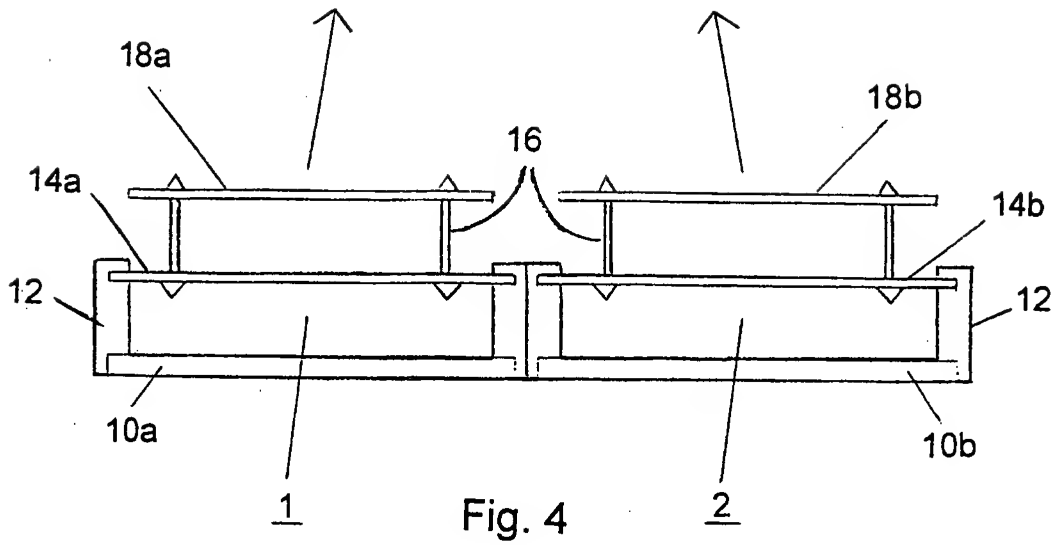

Fig. 4

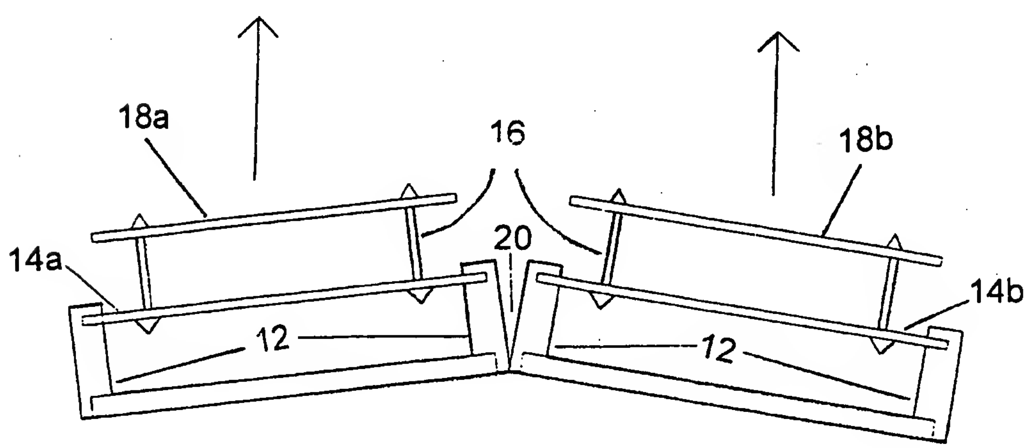

Fig. 5

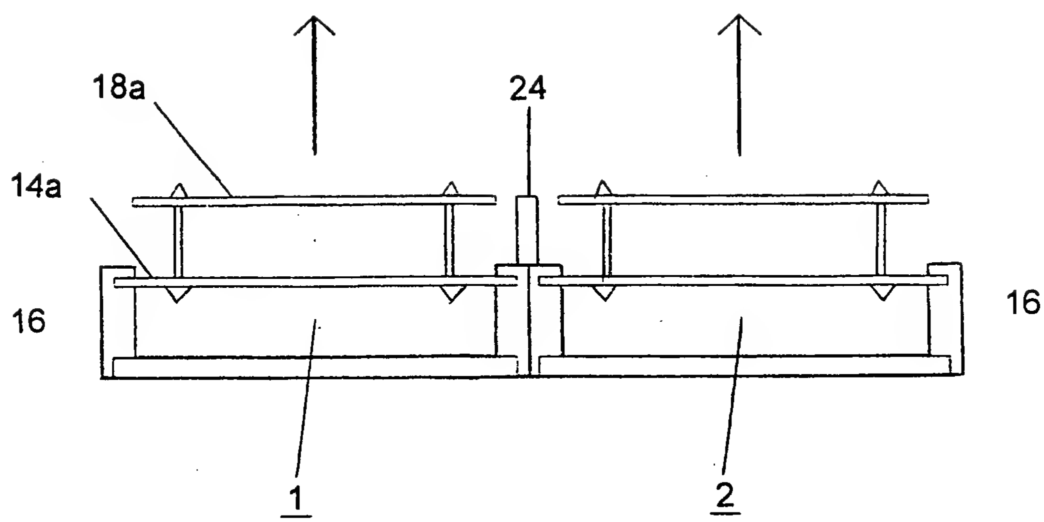

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 99/01875

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H01Q 5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4857938 A (KATSUYA TSUKAMOTO ET AL.), 15 August 1989 (15.08.89), figure 2, abstract	1-5
A		6-8
	--	
X	EP 0360692 A1 (AGENCE SPATIALE EUROPEENNE), 28 March 1990 (28.03.90), figure 3, claim 1, abstract	1-5
A		6-8
	--	
A	EP 0447218 A2 (HUGHES AIRCRAFT COMPANY), 18 Sept 1991 (18.09.91), see the whole document	1-8
	--	

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 March 2000	09-03-2000
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 99/01875

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 8908933 A1 (HUGHES AIRCRAFT COMPANY), 21 Sept 1989 (21.09.89), cited in the description	1-8
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A	GB 1572273 A (ERNEST ROSCOE CASHEN), 30 July 1980 (30.07.80), cited in the description	1-8
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/SE 99/01875

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4857938 A	15/08/89	DE 3835072 A,C	27/04/89
		FR 2622056 A	21/04/89
		GB 2211025 A,B	21/06/89
		JP 1103006 A	20/04/89
		JP 1611947 C	30/07/91
		JP 2039123 B	04/09/90
		NL 190175 B,C	16/06/93
		NL 8802499 A	01/05/89
EP 0360692 A1	28/03/90	CA 1319190 A	15/06/93
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